Factors Influencing Geographic and Seasonal Variations in Light Exposure of Coral Assemblages in the Florida Keys

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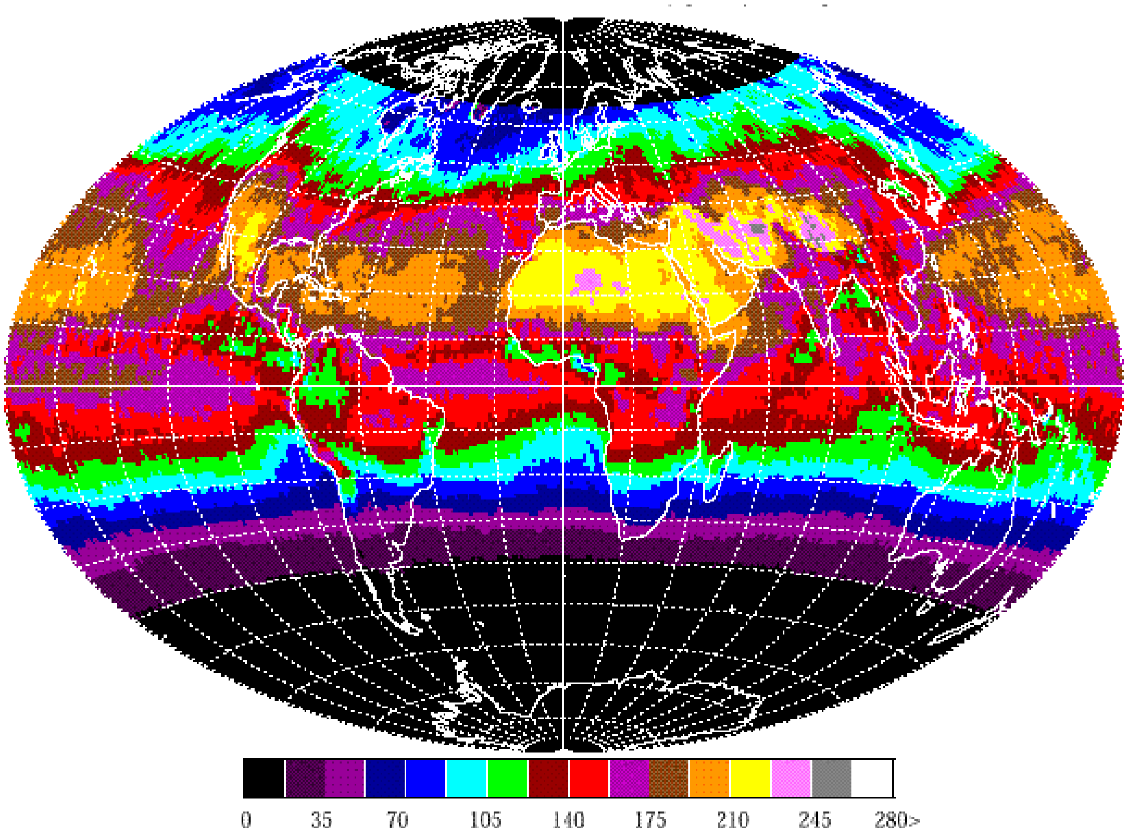
Global Distribution of Surface UV



Corals are in tropics/subtropics where UV is highest and changes in UV-B due to ozone depletion are small:
But important changes in underwater UV may be associated with increased water clarity caused by climate change

Greenhouse Warming and Aquatic UV Exposure

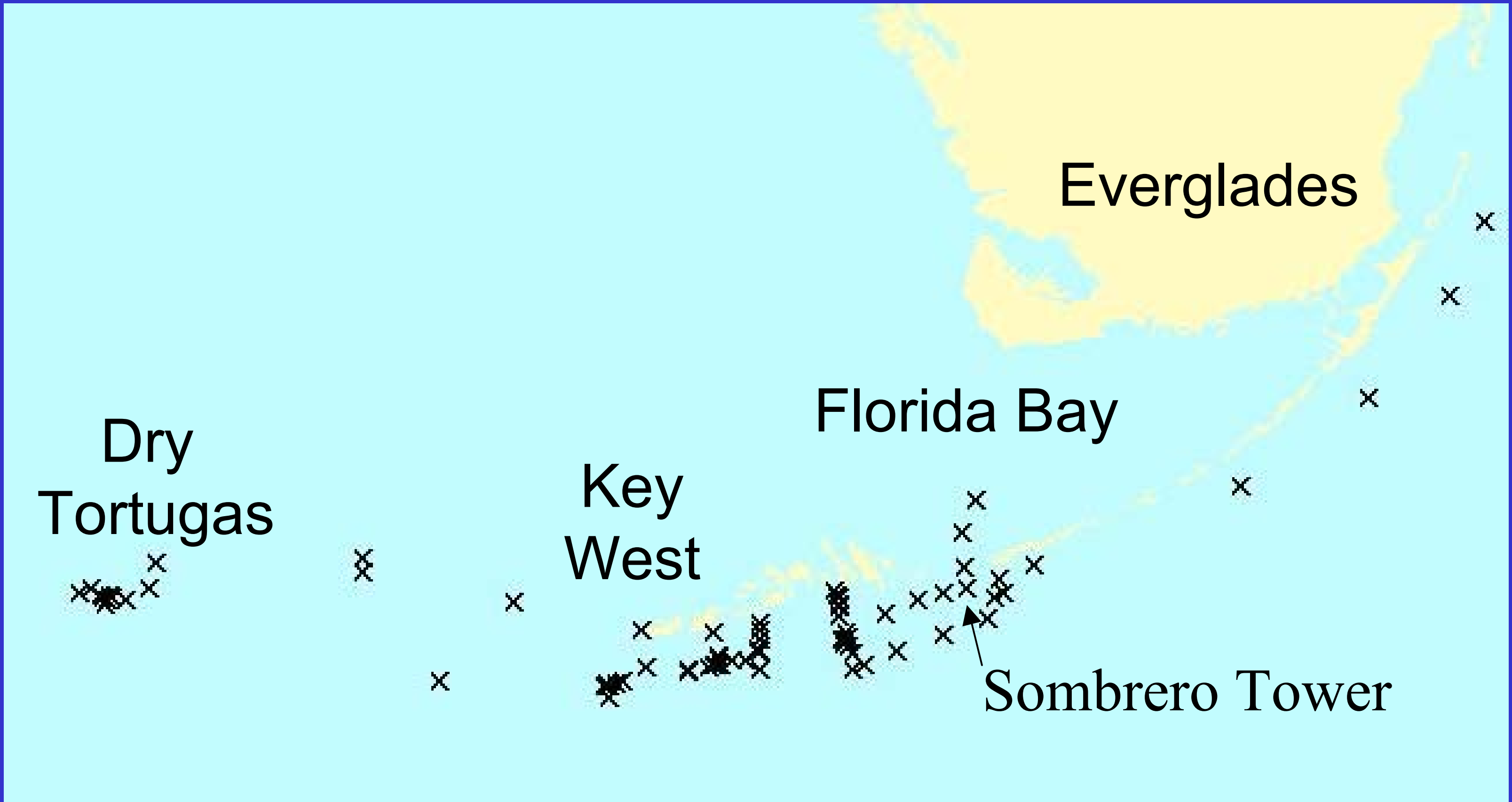
Stratification effects - Stratification can result in increased UV penetration and exposure in the upper water column. Important during ENSO events when corals have extensively bleached?

Precipitation changes - Droughts increase aquatic UV exposure by reducing water depths and runoff of UV-absorbing substances from land.

Increased climatic variability – Increased fluctuations in precipitation frequency and amount can enhance the variability in aquatic UV exposure thus reducing ability of organisms to adapt

Biological changes - Biological sources of UV absorbing substances likely will change with greenhouse warming

Map Illustrating Sites Investigated in Florida Keys

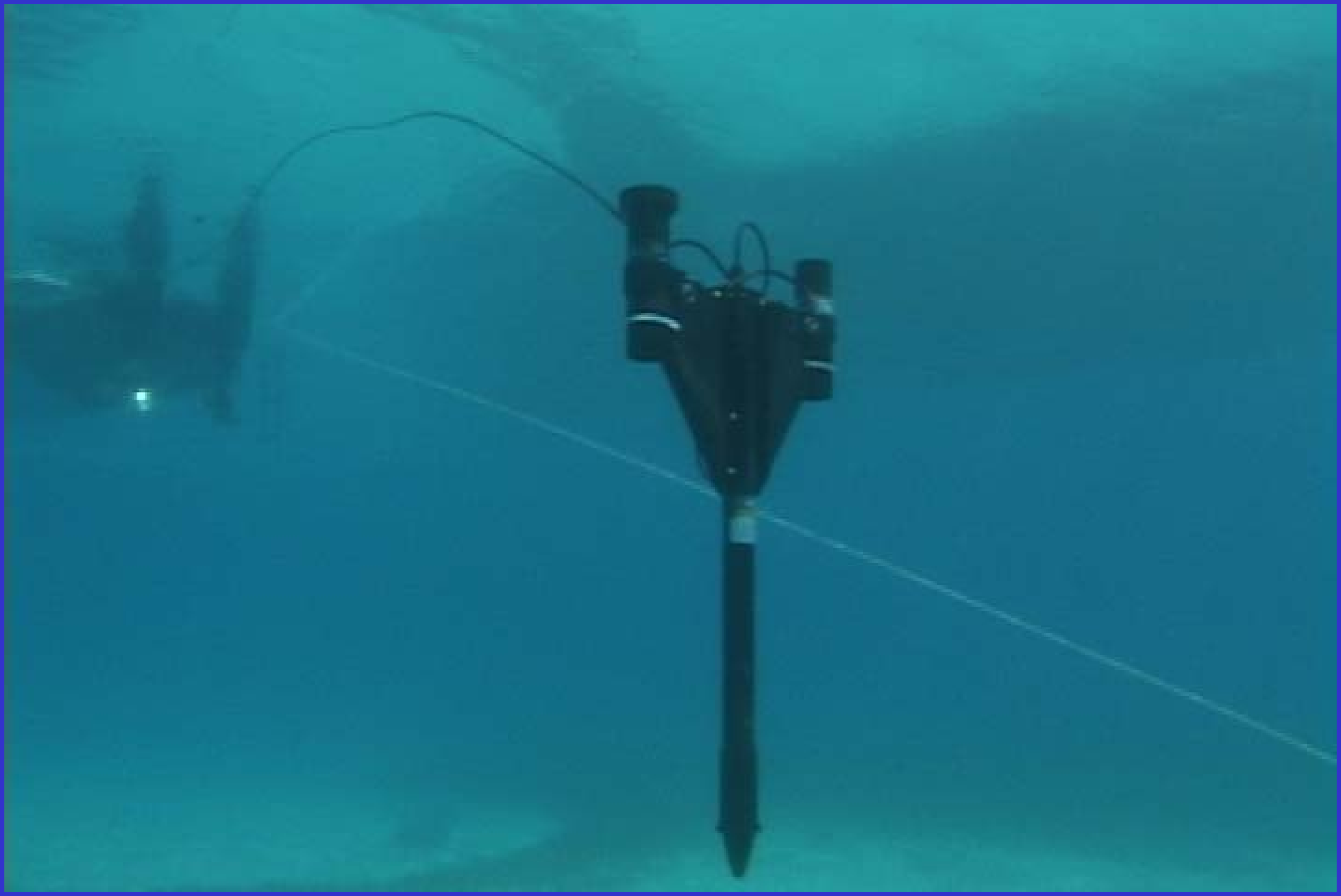


Lower Keys Sites Included in Corals Research

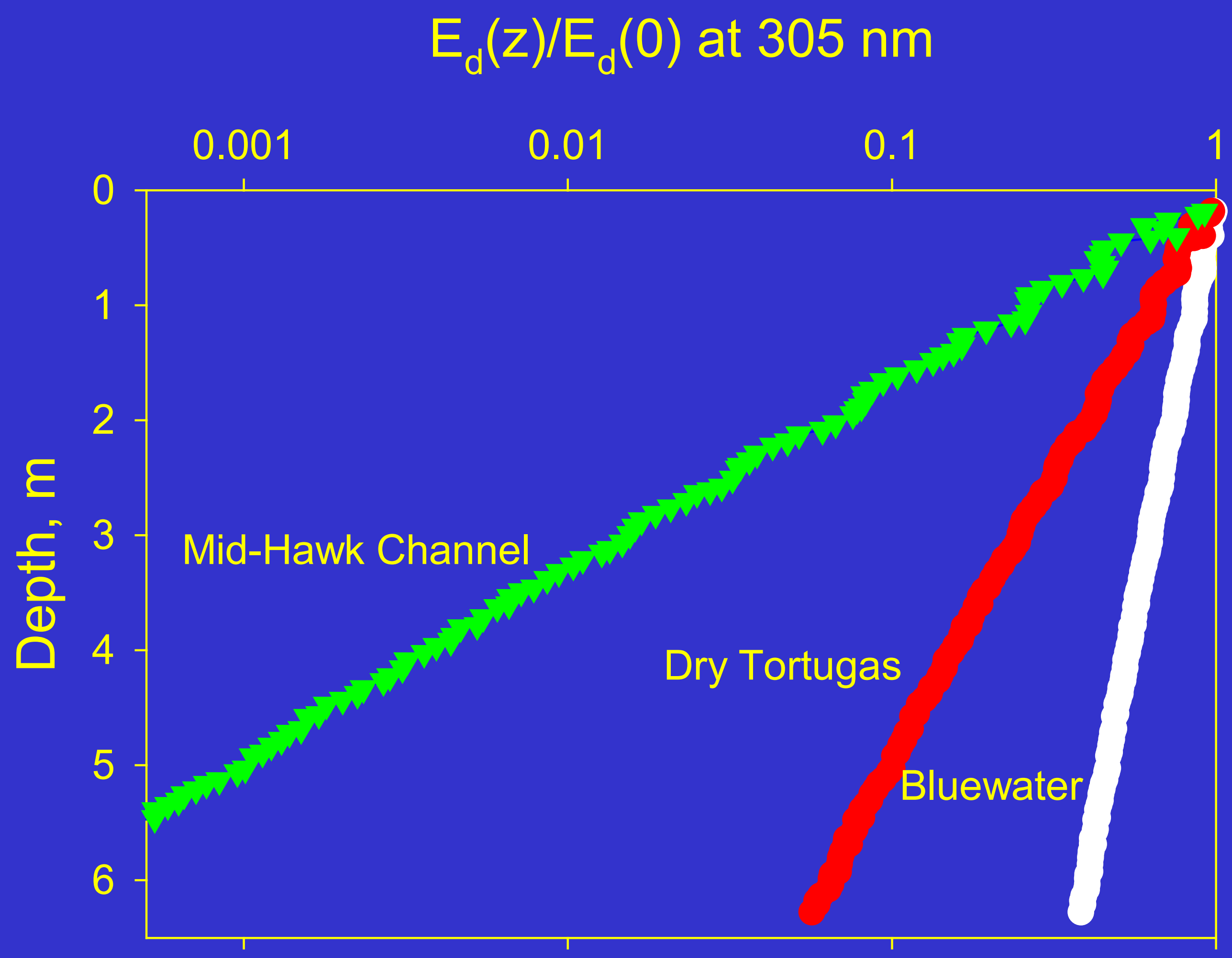
Equation That Describes Penetration Of Solar UV Irradiance Into the Sea (Exponential decrease with depth)

$$E_d(z, \lambda) = E_d(0, \lambda)\, e^{-K_d(\lambda) * z}$$

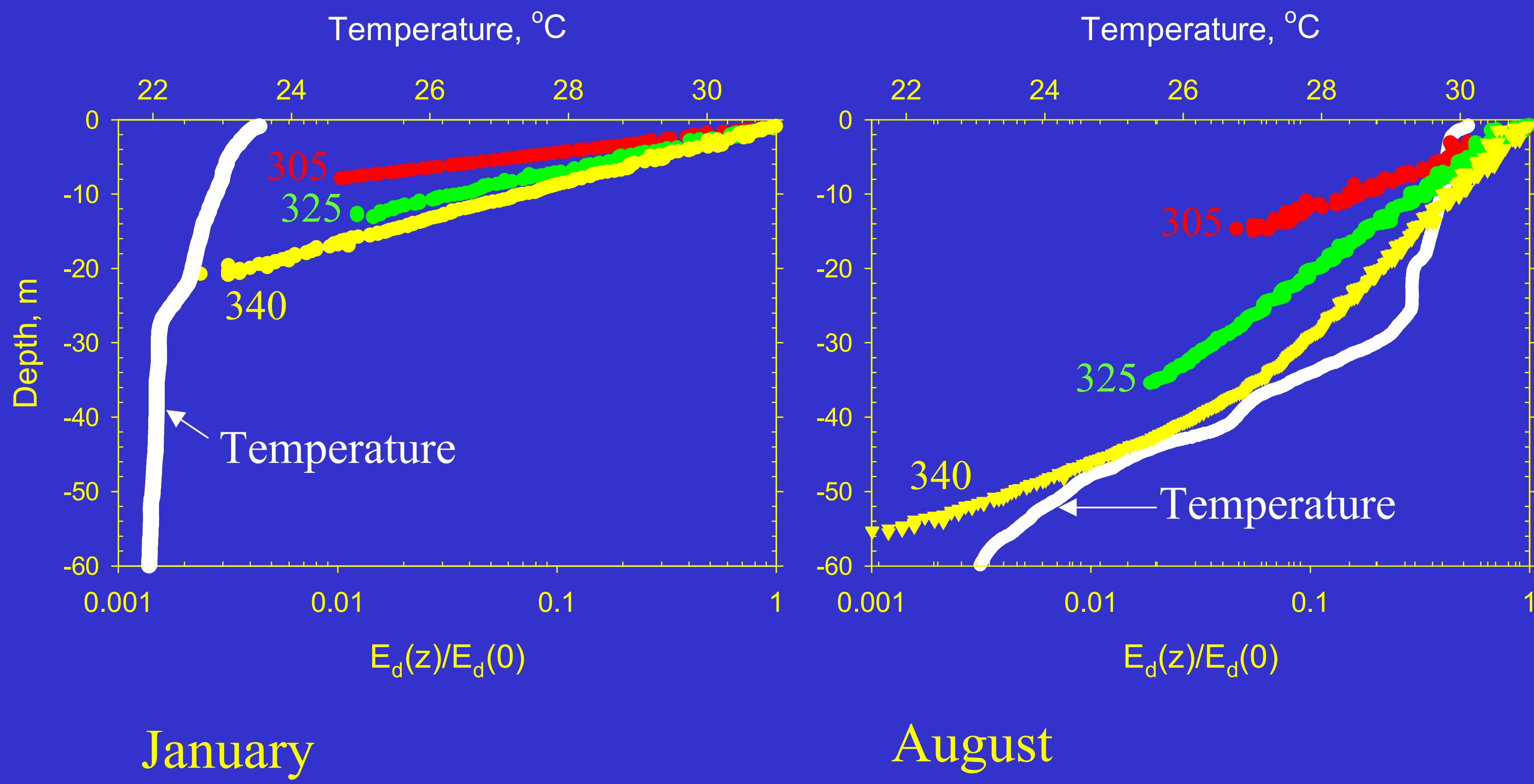
Satlantic MicroPro Optical Profiler Used for Part of UV Depth Profiling



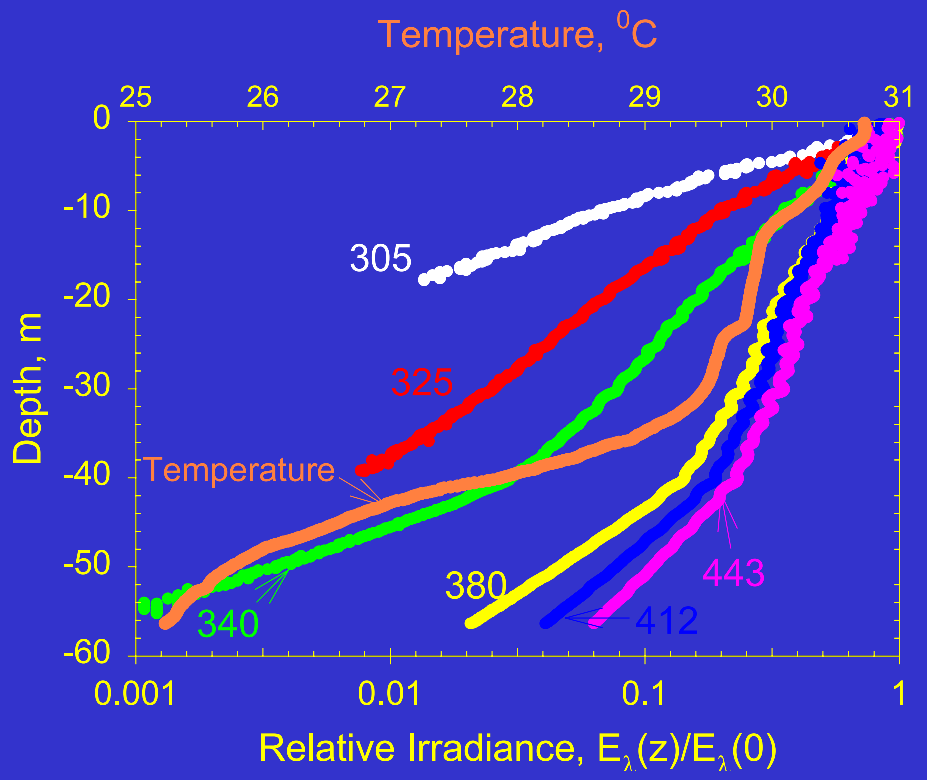
UV-B Irradiance Vs. Depth in the Florida Keys



Seasonal Variation in the Temperature and UV vs Depth Profiles at a Site Near Looe Key Coral Reef, Florida Keys

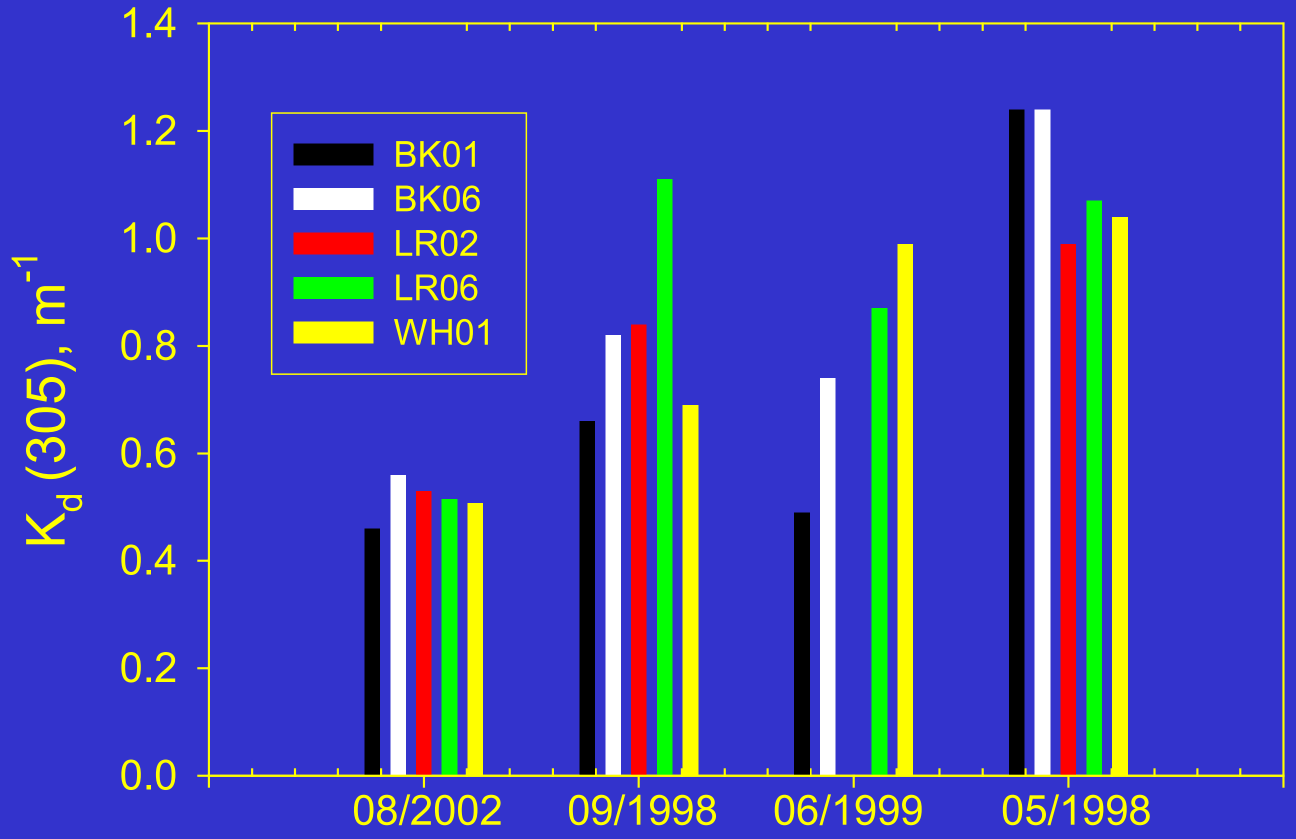


Solar Irradiance and Temperature vs. Depth in the Atlantic South of Maryland Shoals, Florida Keys (Shows stratification effect on UV penetration)

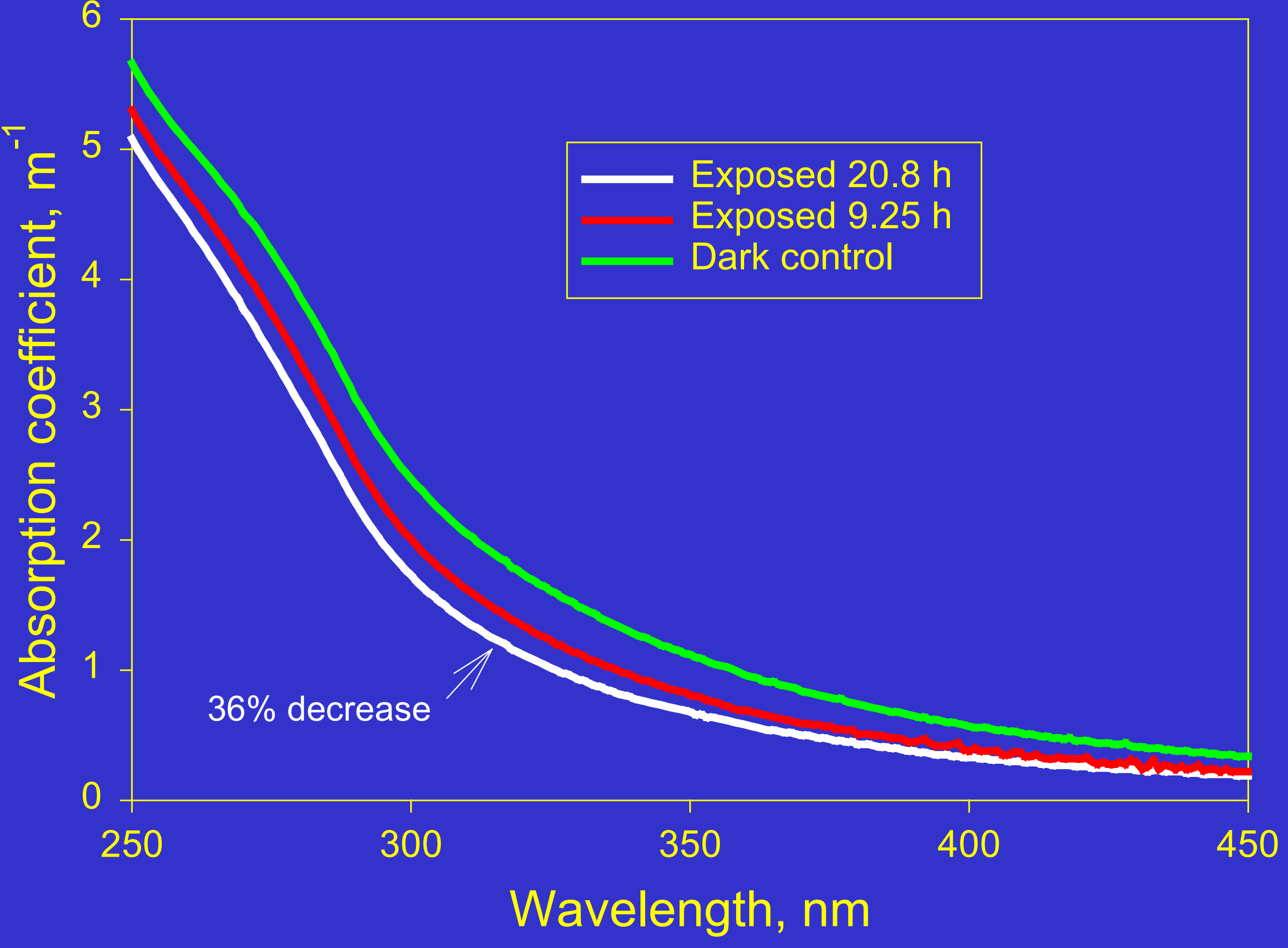


Observed 3-fold decrease in CDOM conc. above thermocline corresponds to 8-fold increase in UV-B exposure at depth of 4 m

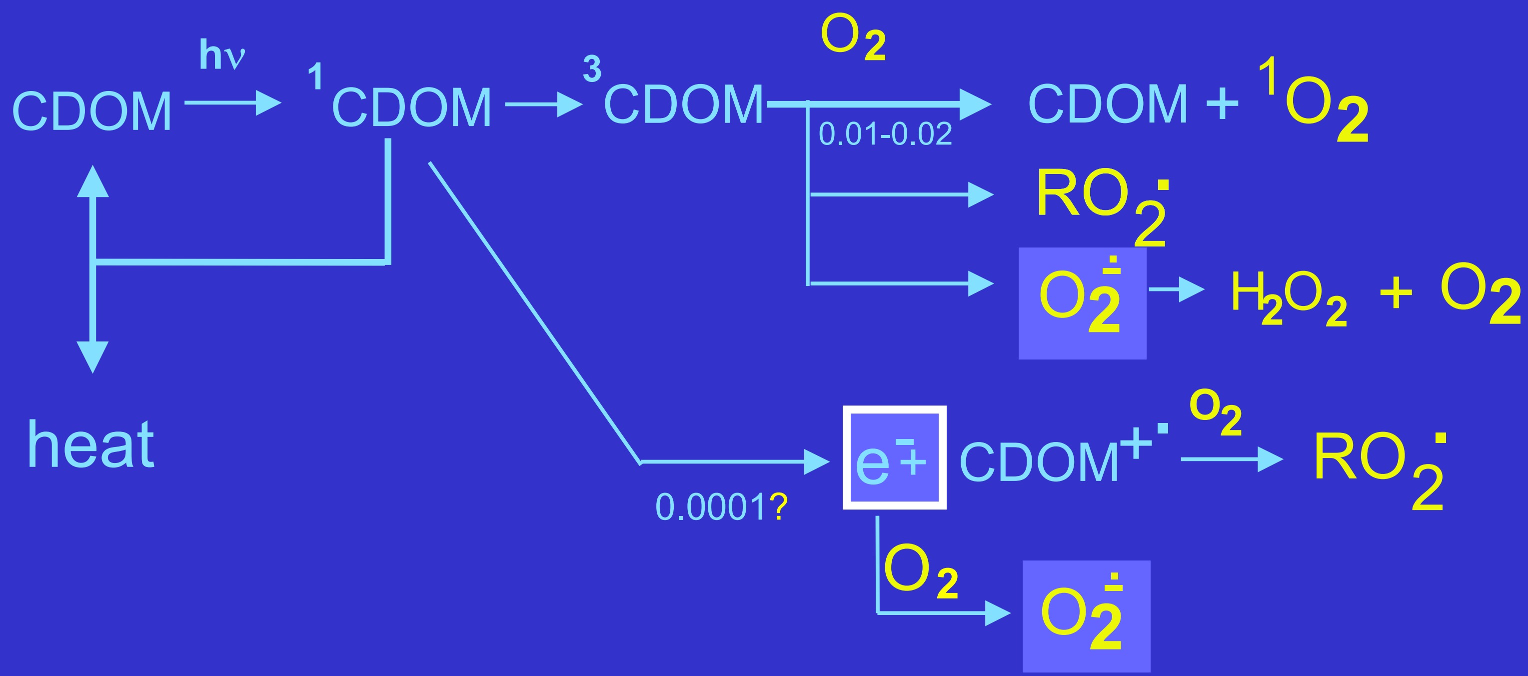
Diffuse Attenuation Coefficients for Corals Sites in Dry Tortugas



Photobleaching of Water from Hawk Channel Exposed to Solar Radiation



UV-Induced Production of ROS From CDOM



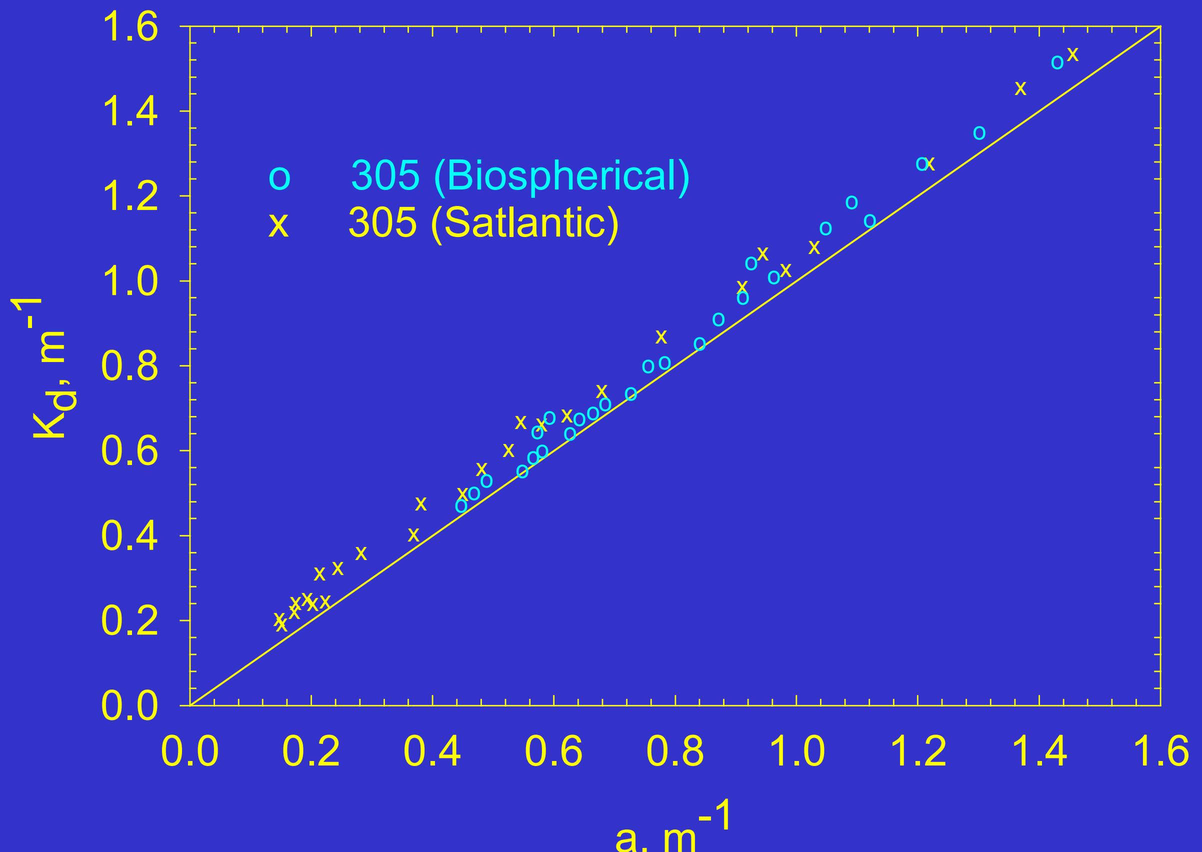
ROS = reactive oxygen species

Definition of Absorption Coefficient

$$a_? = 2.303\ A_? / l$$

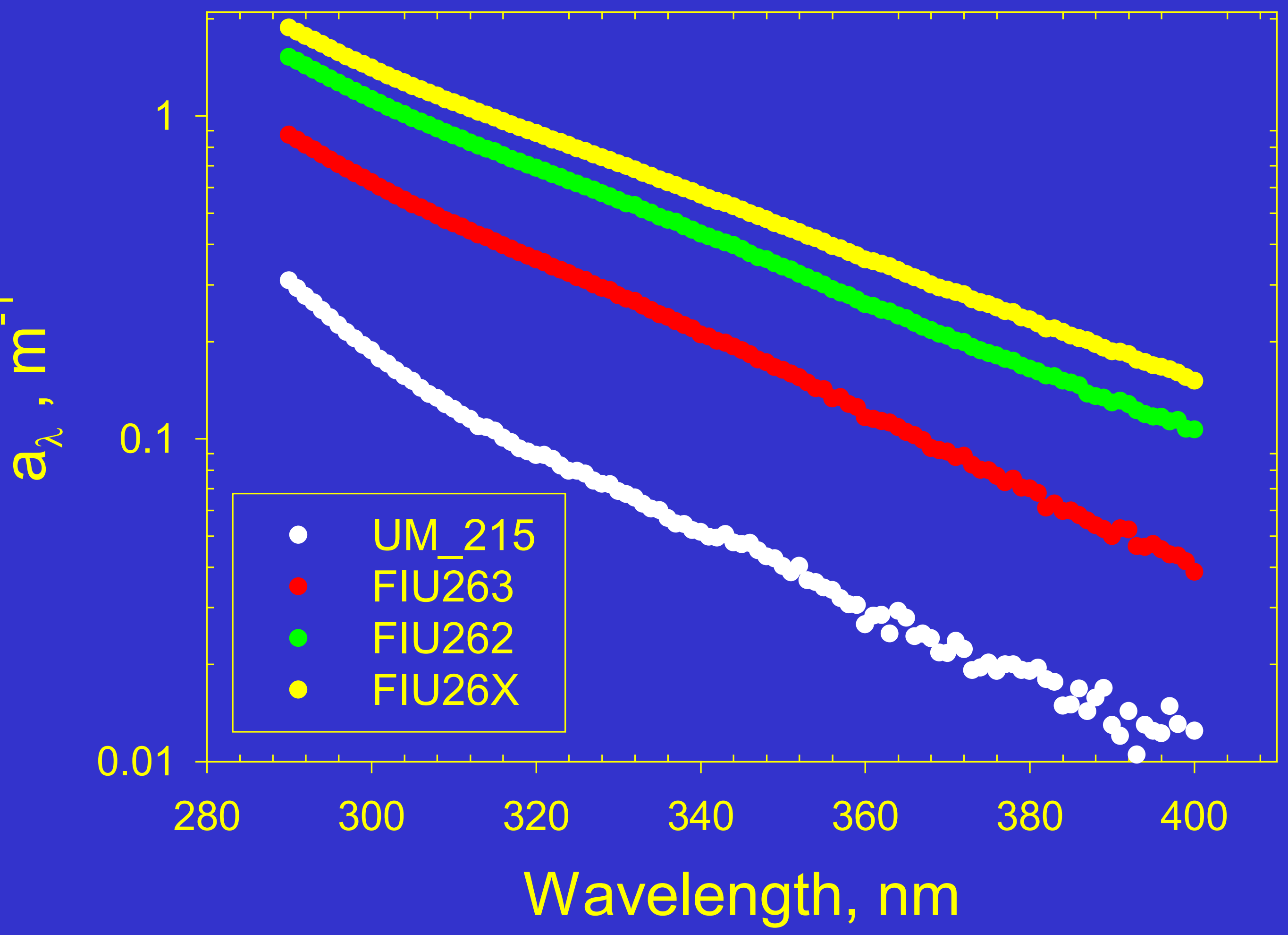
where $a_?$ is the absorption coefficient at wavelength ?,
$A_?$ is the absorbance of a filtered water sample (0.2 µm)
and l is the light pathlength in meters

Comparison of Diffuse Attenuation and CDOM Absorption Coefficients For Florida Keys Sites (shows that CDOM controls UV-B penetration)



CDOM is UV absorbing component of dissolved organic matter

Absorption Spectra of Water Obtained Along S – N Transect Near Looe Key, Florida Keys

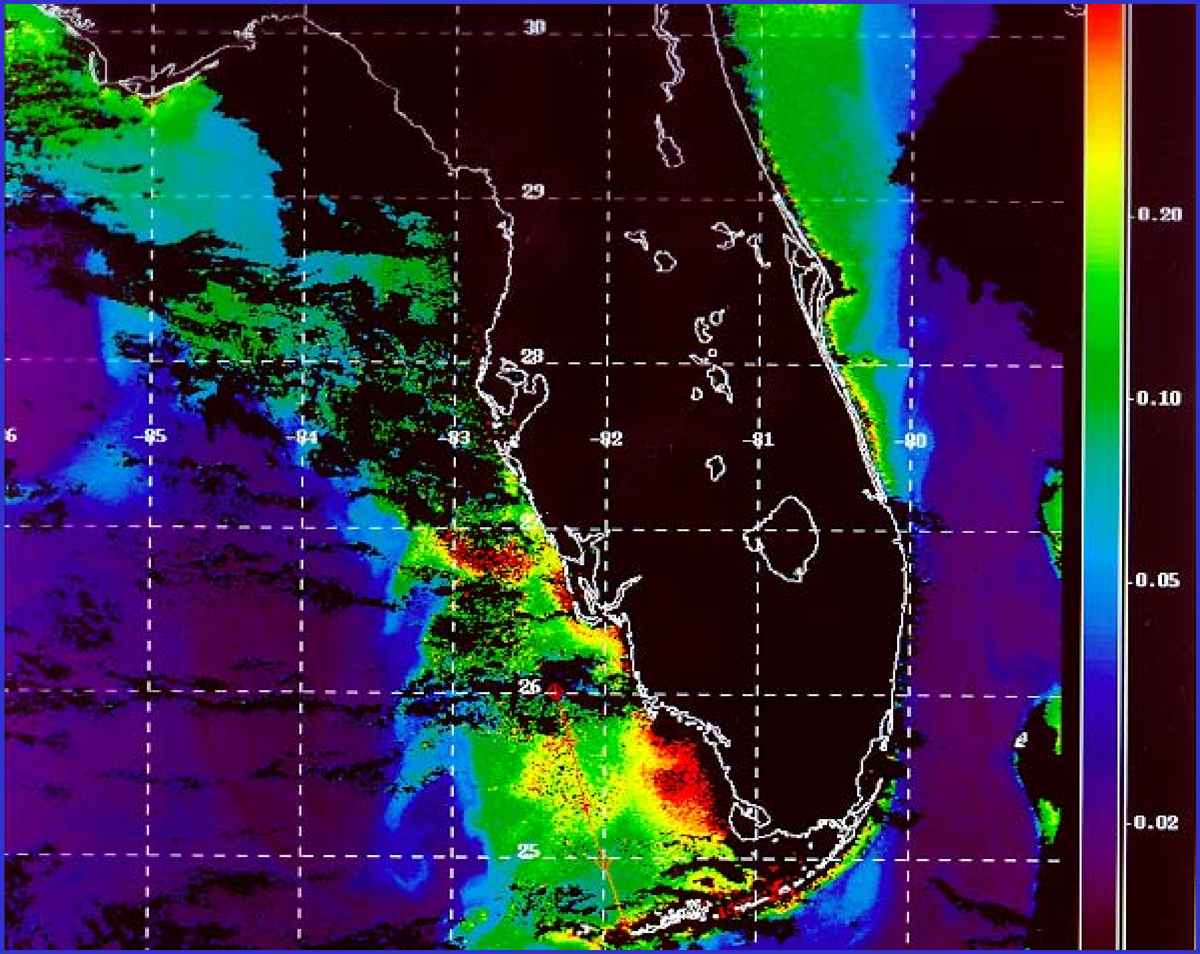


Non-linear Exponential Equation That Describes Absorption Spectra of Florida Keys CDOM

$$a(\lambda) = b + a(\lambda o)\exp[-S(\lambda - \lambda o)]$$

For Florida Keys waters:
Over reefs, S is 0.021-0.036
Closer to land S is 0.016-0.019

Colored Dissolved Organic Matter (CDOM) Estimated from SeaWIFS Data and Directly Measured (June 2, 1998) (Carder et al., 1999)



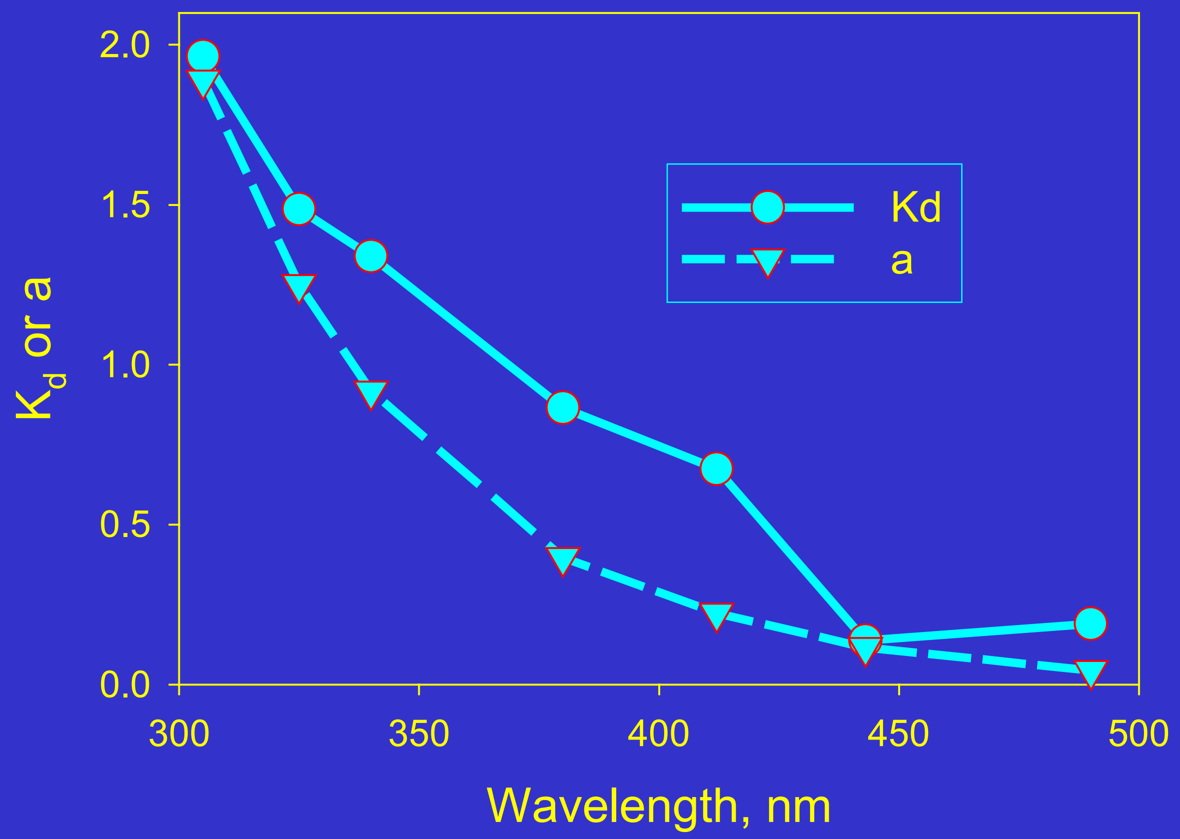
Relationship Between Diffuse Attenuation Coefficient And Absorption and Scattering Coefficients

$$K_d = (a^2 + 0.256\ ab)^{1/2}$$

Part affected by particle scattering

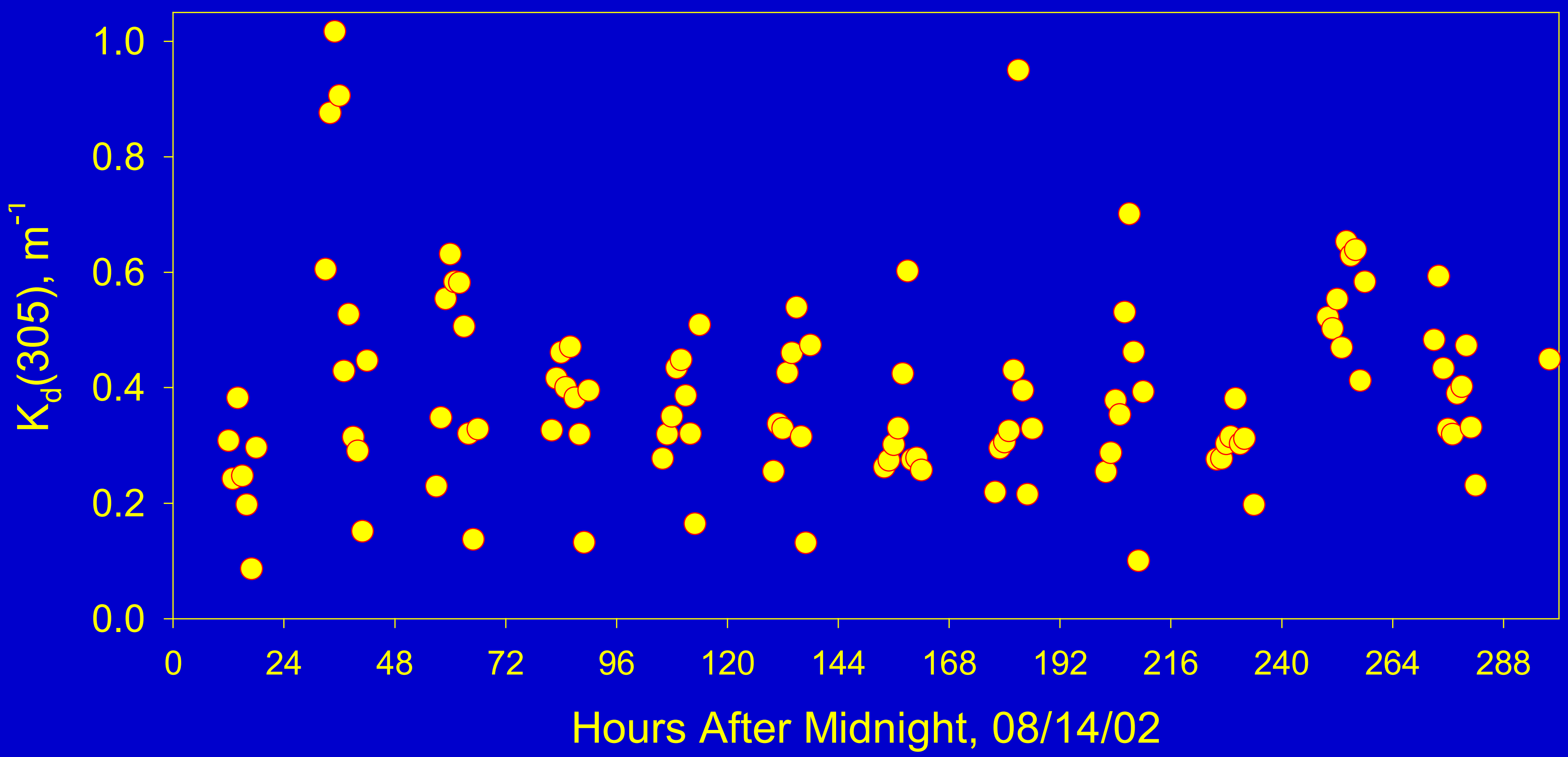
Kirk, 1983

Diffuse Attenuation Coefficient Spectra Compared To Absorption Spectra for Mid-Hawk Channel

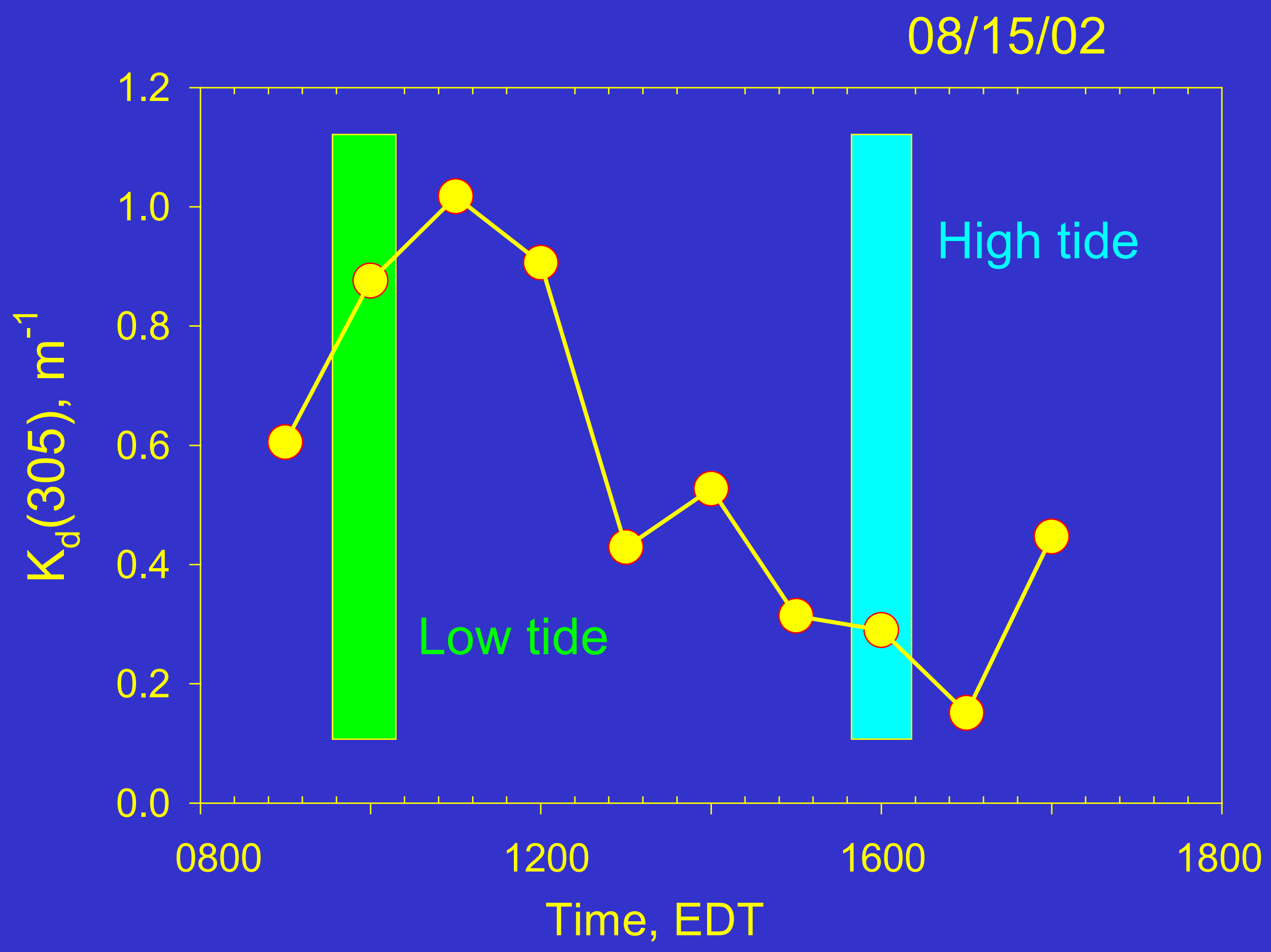


Sombrero Tower Site, Florida Keys

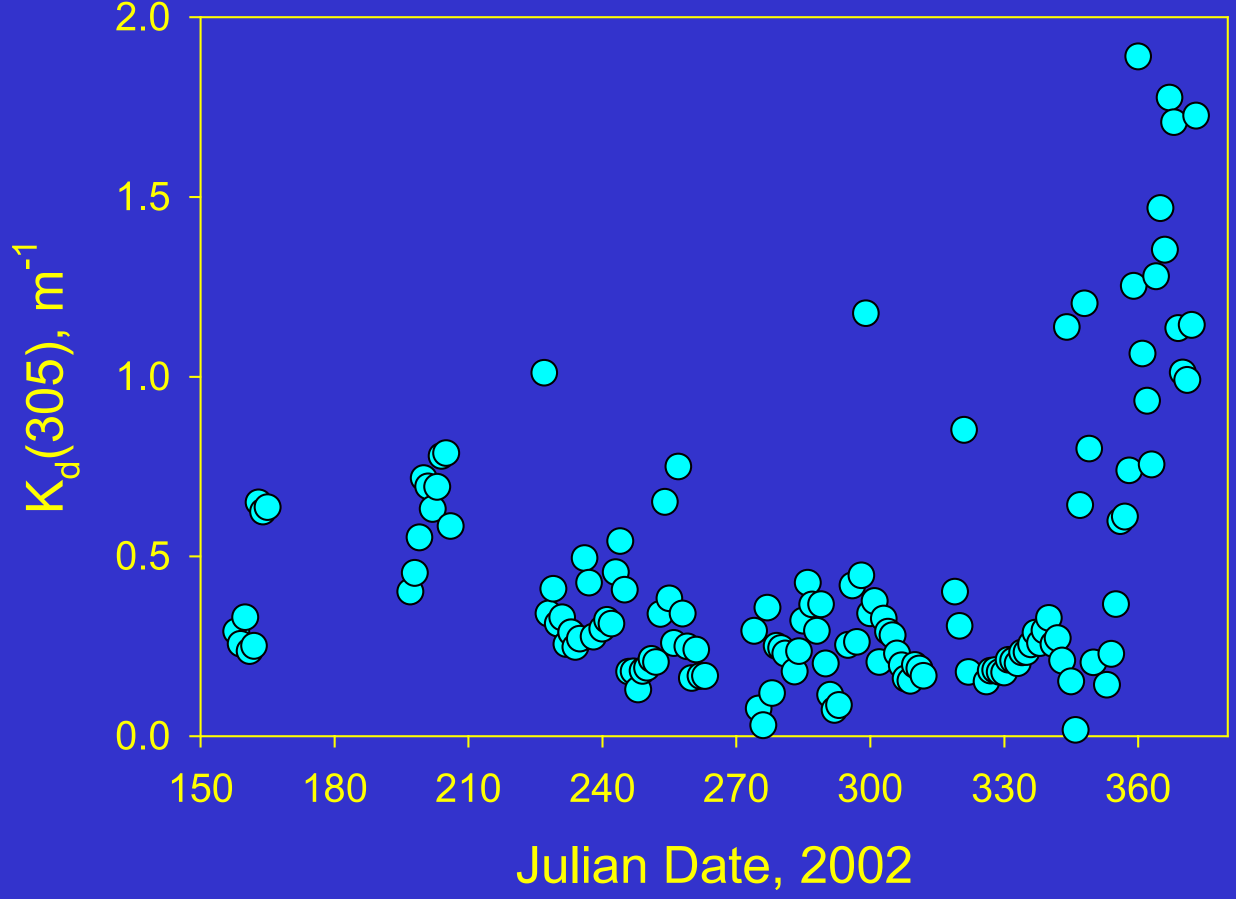
Diurnal Variation in UV-B Diffuse Attenuation Coefficient (305 nm) During August at Sombrero Tower, Florida Keys



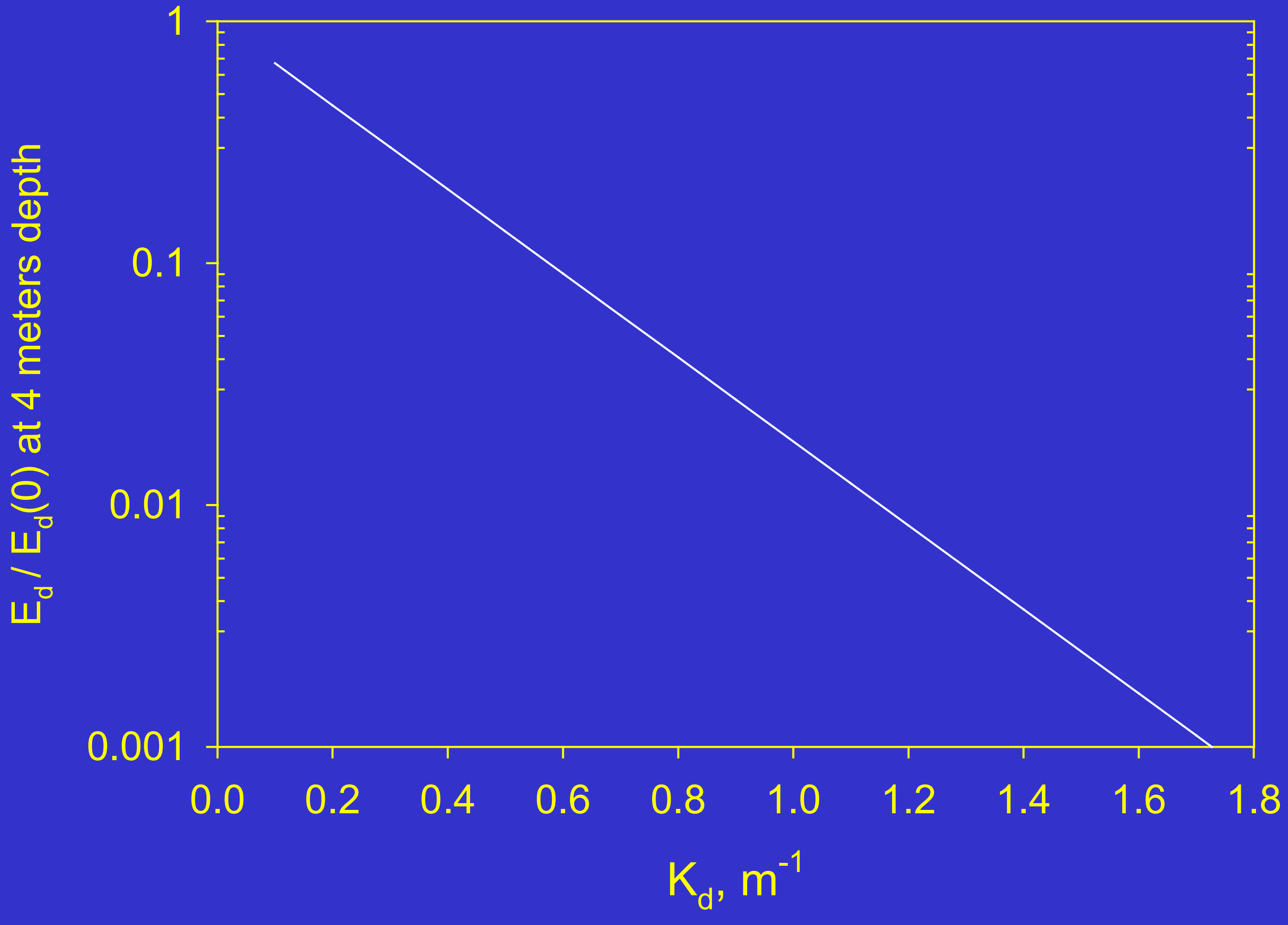
Diurnal Variation in UV-B Diffuse Attenuation Coefficient (305 nm) at Sombrero Reef



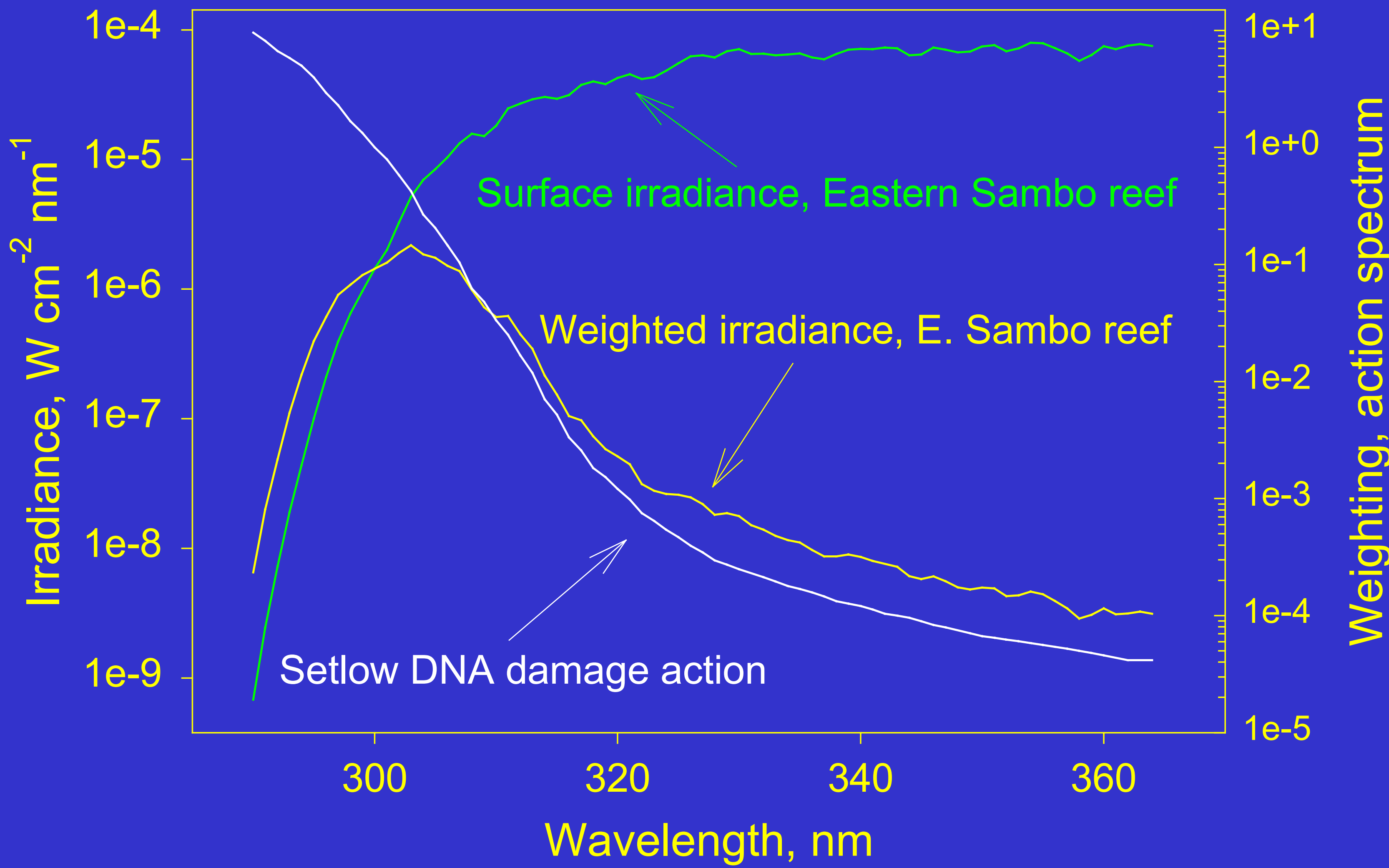
Midday UV-B (305 nm) Diffuse Attenuation Coefficients at Sombrero Tower



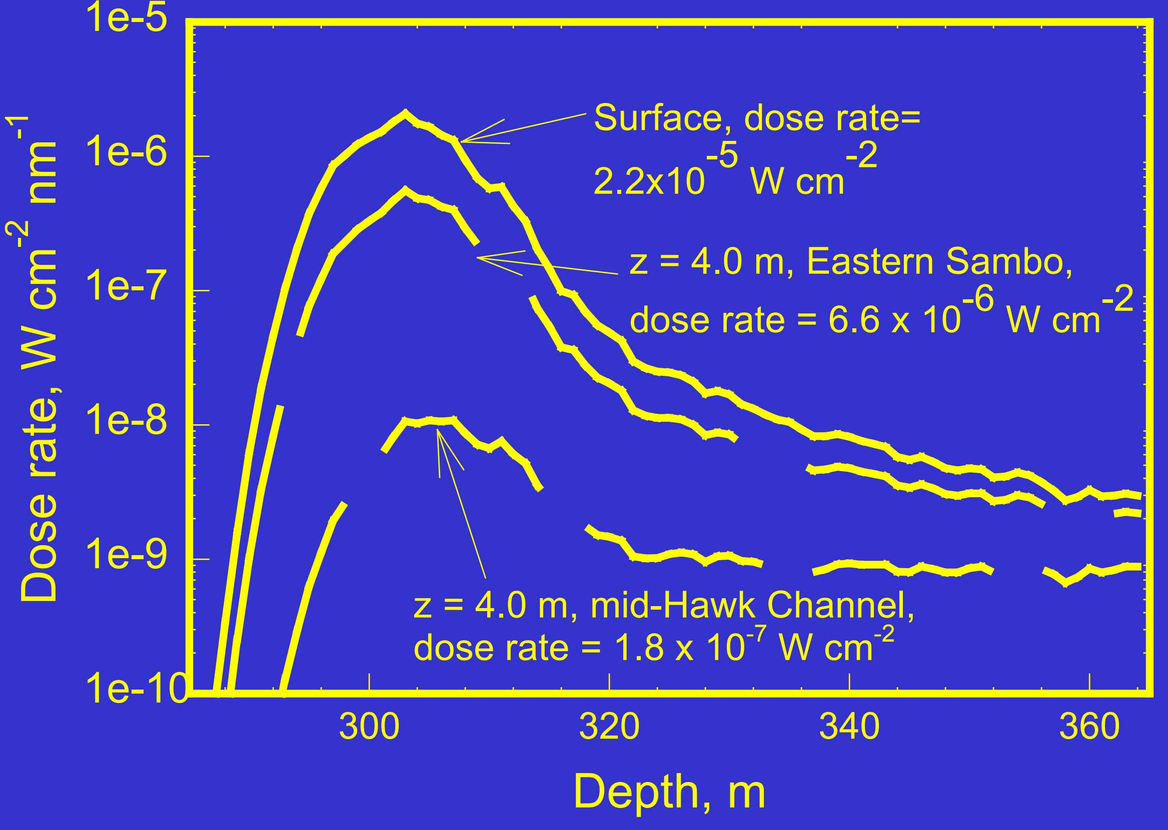
Relationship Between Drop-off in Irradiance With Depth and Diffuse Attenuation Coefficient



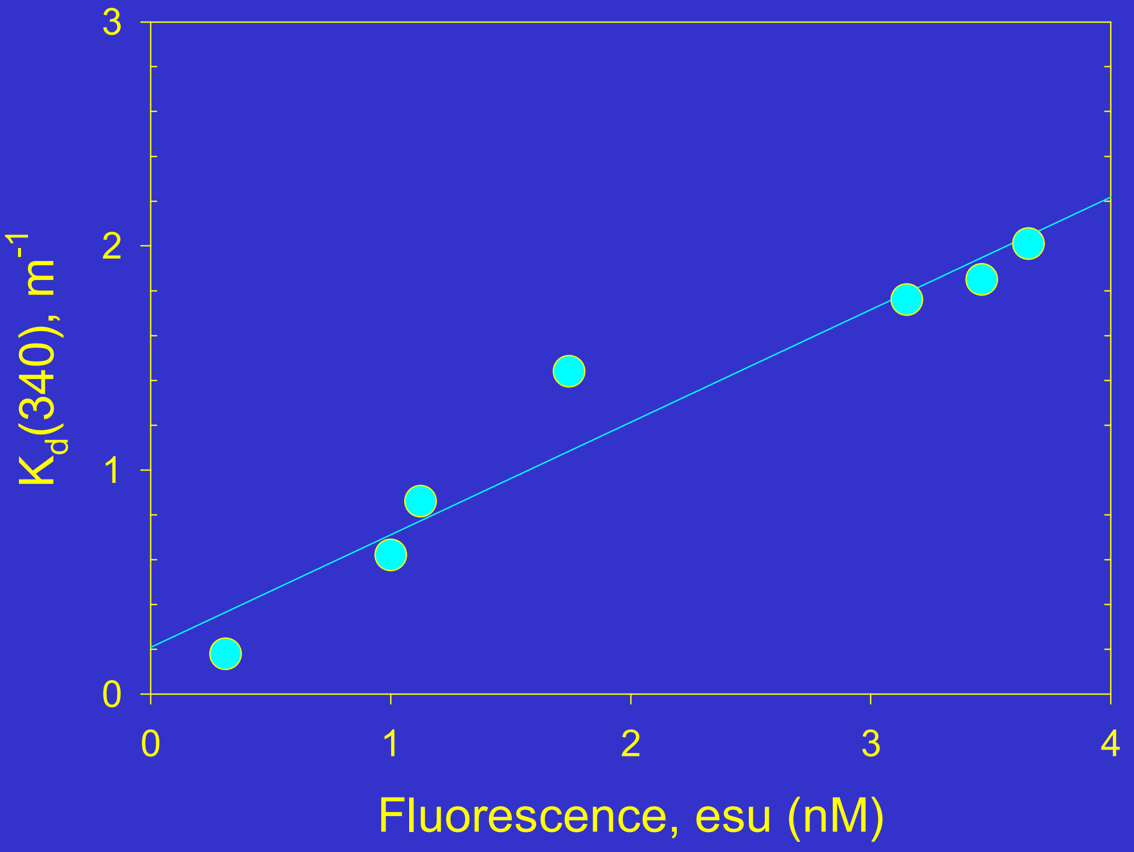
Comparison of Setlow Action Spectrum and Solar Spectral Irradiance at Eastern Sambo Reef, Florida Keys, July 1999

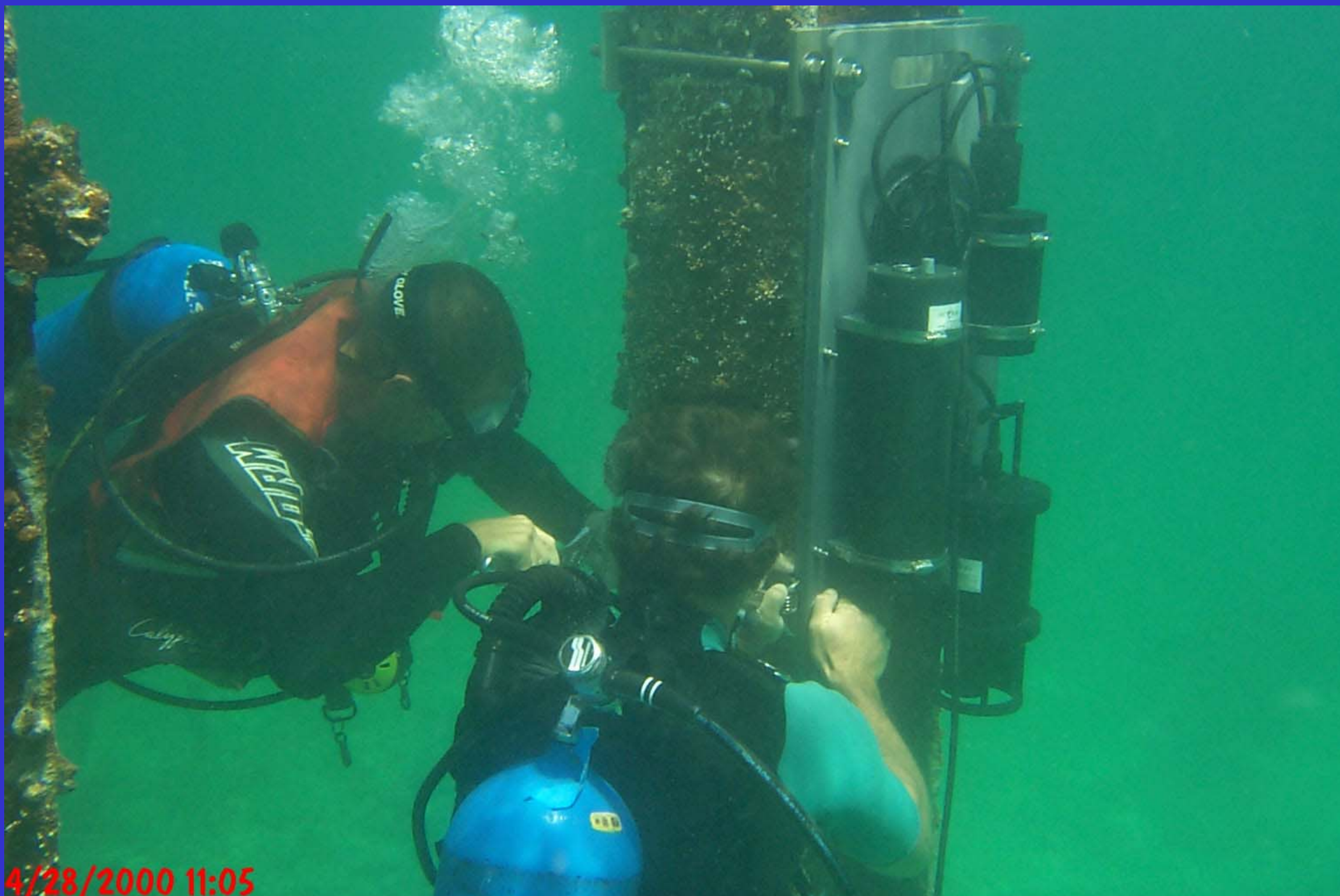


Estimated Exposure to DNA-Damaging Solar UV-B Irradiance Vs. Depth



Relationship Between UV Diffuse Attenuation Coefficients (340 nm) and Fluorescence Along Transect Across Hawk Channel, Florida Keys

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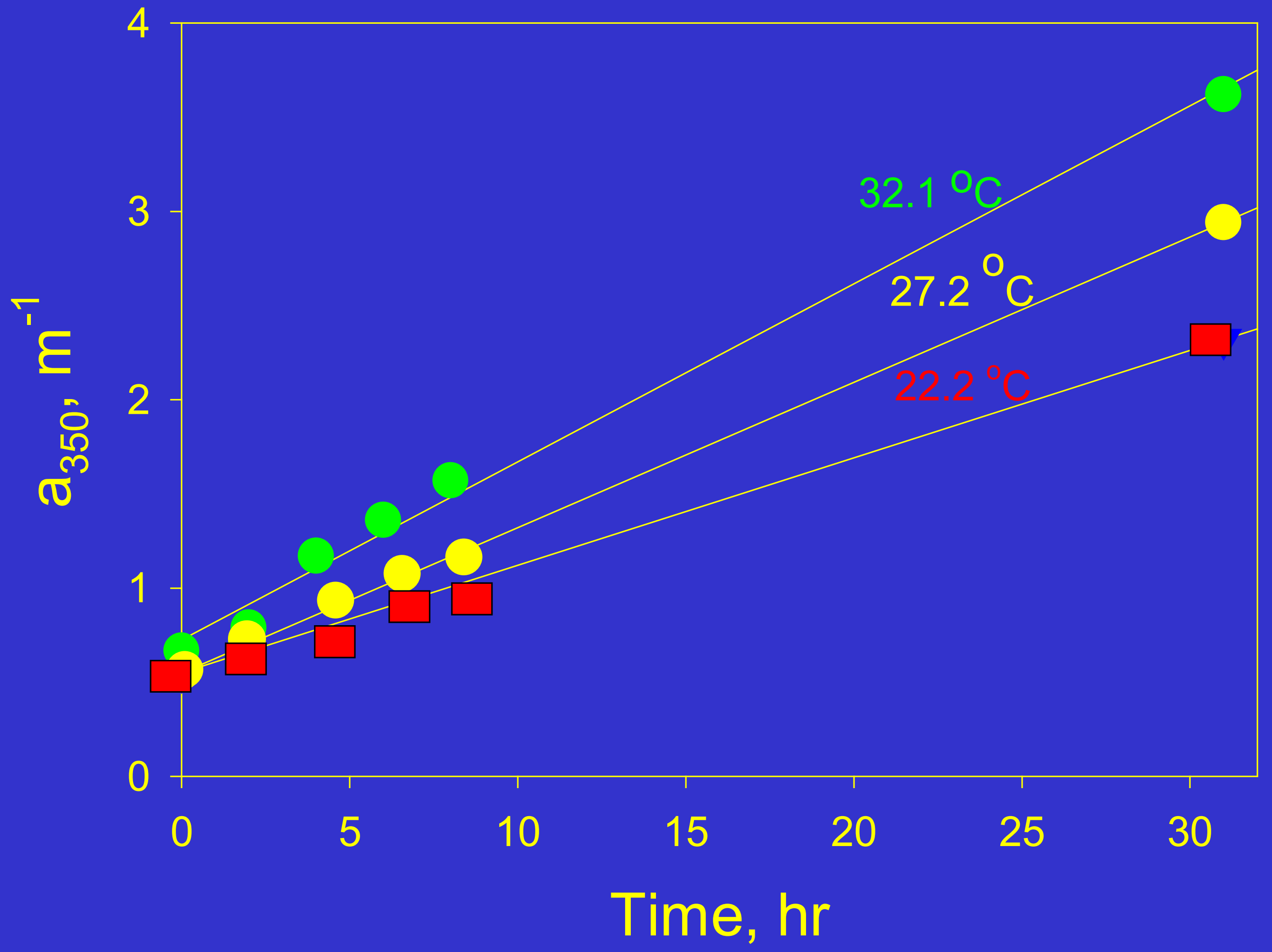
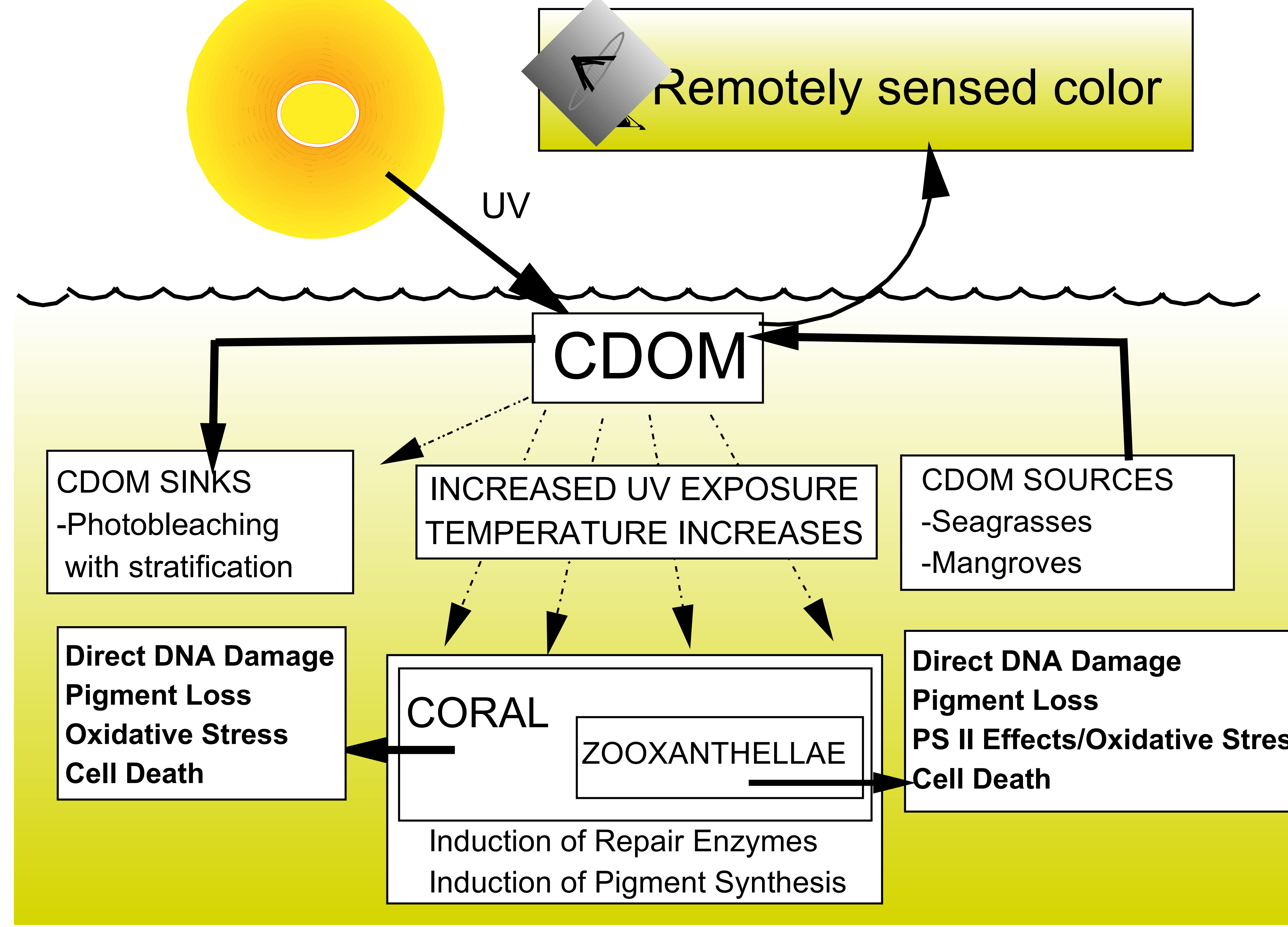
Potential Sources of UV-Absorbing Substances in Water

- Local: Mangroves and underwater plants, e.g. sea grasses
- Transport of CDOM from Florida Bay and southwest Florida coast
- Detritus decay in bluewater outside reefs
- Particulates, e.g. detritus

Sampling Procedure For Grass Flux Studies Near Looe Key

Temperature Effects on the Production of CDOM from *Thalassia testudinum* Litter




Remotely sensed color
UV
CDOM
CDOM SINKS
-Photobleaching
with stratification
INCREASED UV EXPOSURE
TEMPERATURE INCREASES
CDOM SOURCES
-Seagrasses
-Mangroves
Direct DNA Damage
Pigment Loss
Oxidative Stress
Cell Death
CORAL
ZOOXANTHELLAE
Induction of Repair Enzymes
Induction of Pigment Synthesis
Direct DNA Damage
Pigment Loss
PS II Effects/Oxidative Stres
Cell Death

Conclusions

- CDOM transported over the coral reefs plays key role in controlling UV exposure
- Calm, stratified conditions enhance UV penetration caused by CDOM photobleaching (seasonal, ENSO?)
- Particles play important role in attenuating UV in coastal shelf region (Hawk Channel)
- Near shore mangroves and seagrasses are major CDOM sources in Florida Keys

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